Nutrient Load Reduction Targets approach to reach WFD-targets

Methods to quantify Load Reduction Targets (LRT) for nutrients in surface water bodies

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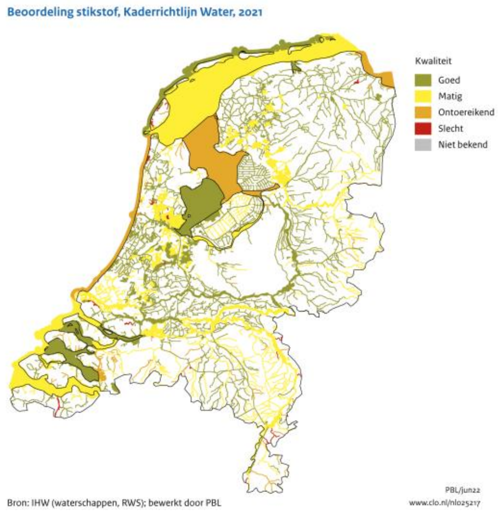
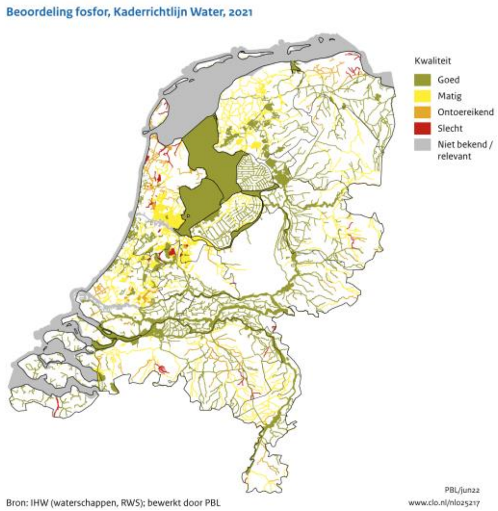
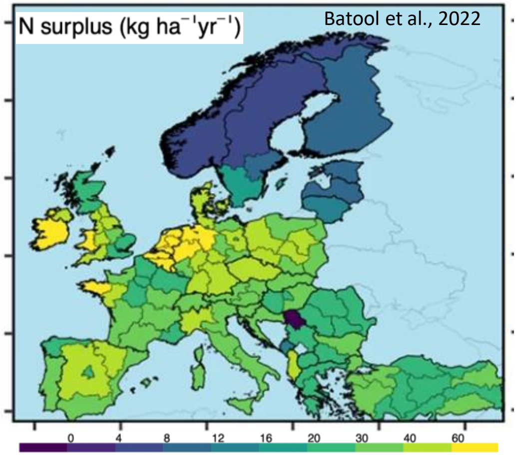
Harmonica

Why load reduction Nutrients?







- High N and P loads hamper good ecological condition in many surface water bodies
- The impact can be partly reduced by retention measures, but significant reduction is often difficult, so load reduction is required

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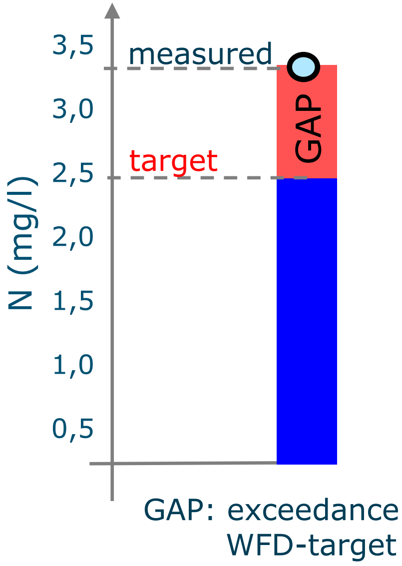
The principle of Load Reduction Targets

LRT in the catchment of a Surface Water Body (SWB)

- GAP = % exceedance WFD-target concentration
- LRT = GAP * total loads
- Assumption: Δ load in SWB (%) = Δ concentration SWB near outlet (%) (no change Q)



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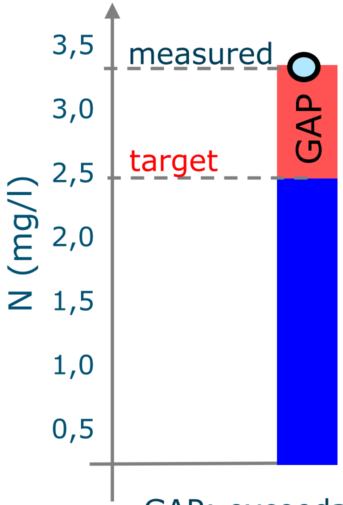
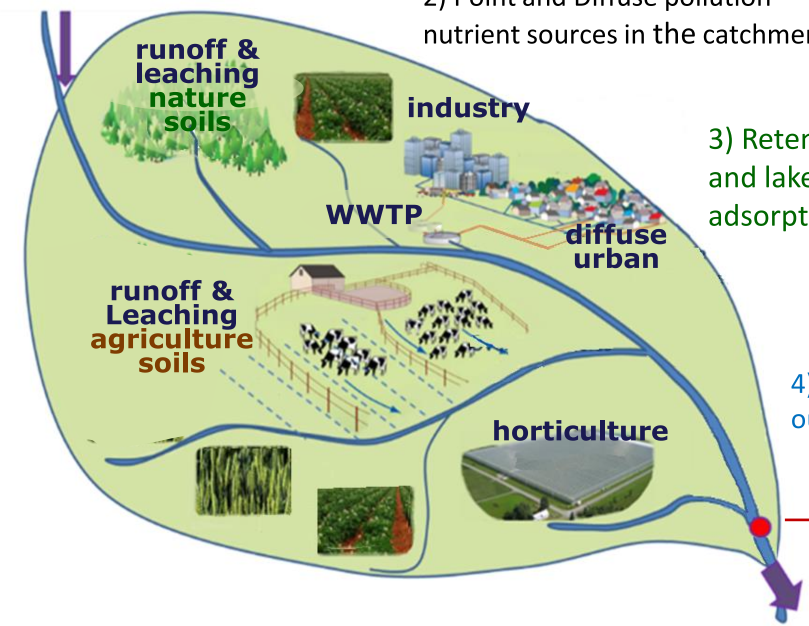
The principle of Load Reduction Targets



GAP: exceedance
WFD-target



Measured: 4,0 mgN/l
WFD target: 3,0 mgN/l
- GAP = 1,0 mgN/l, or 25%
- LRT: 25%

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The principle of load reduction targets

Definition:

Load Reduction Target (LRT) = reduction of the total load needed to meet the WFD-target concentrations in the surface water body

$$\text{LRT [kg N]} = \frac{\text{average observed} \; - \; \text{WFD target concentration}}{\text{average observed concentration}} \frac{\text{[mg/l]}}{\text{[mg/l]}} \text{ x } \left(\sum_{source1}^{source\ n} Load_{source} * SWR_{source} \text{ [kg N]} \right)$$

Important assumptions when applied:

→ GAP: WFD monitoring point near outlet (downstream)

→ Loads: based on measurements or model outcome $\sum discharges * \ conc \ = \sum_{t=0}^{t=1\ year} Q_t * \ C_t$

→ Averaged measured concentrations are often not flow-weighted concentrations

→ Do policy makers want to divide the LRT over the polluting sectors?

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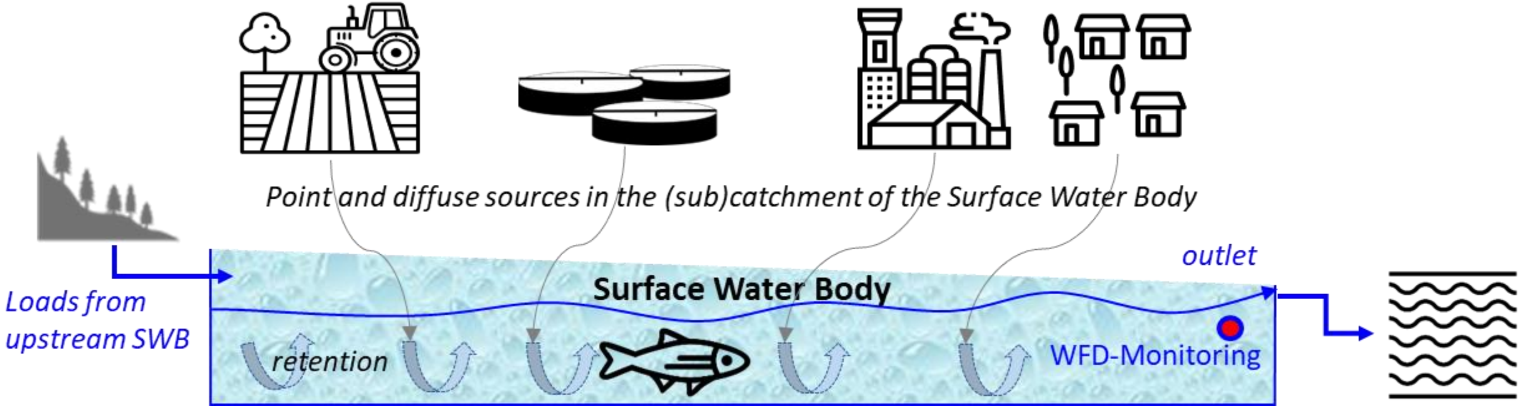
The Dutch method to quantify LRT:

LRT : GAP * load

GAP : based on de observed concentrations at the WFD monitoring site.

Loads : modelled point and diffuse sources within the catchment plus the loads that are modelled as outlet from the upstream SWB.

$$\text{LRT [kgN]} = \frac{\text{measured} - \text{WFD target concentration}}{\text{measured concentration}} \frac{[\text{mg/l}]}{[\text{mg/l}]} \text{ x total load [kgN]}$$



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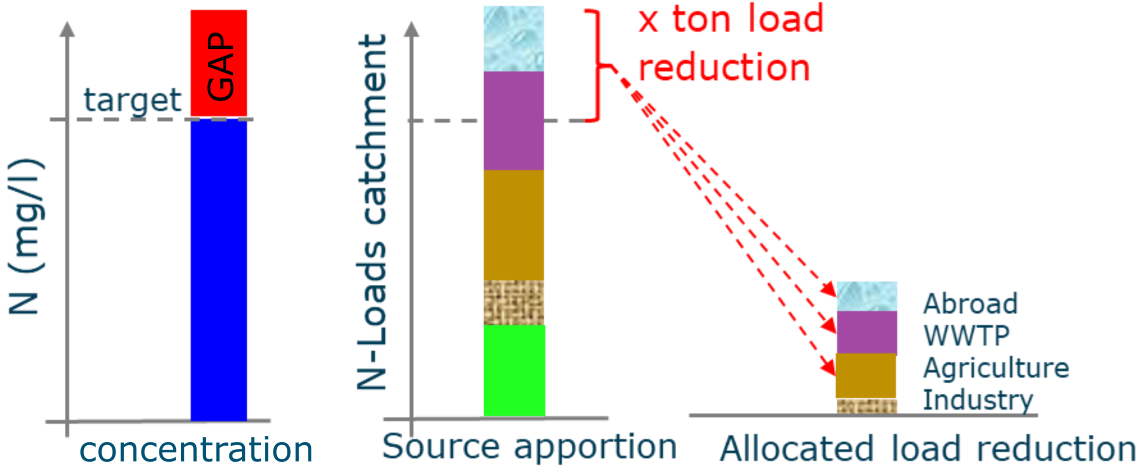
The Dutch method to allocate LRT to sectors:

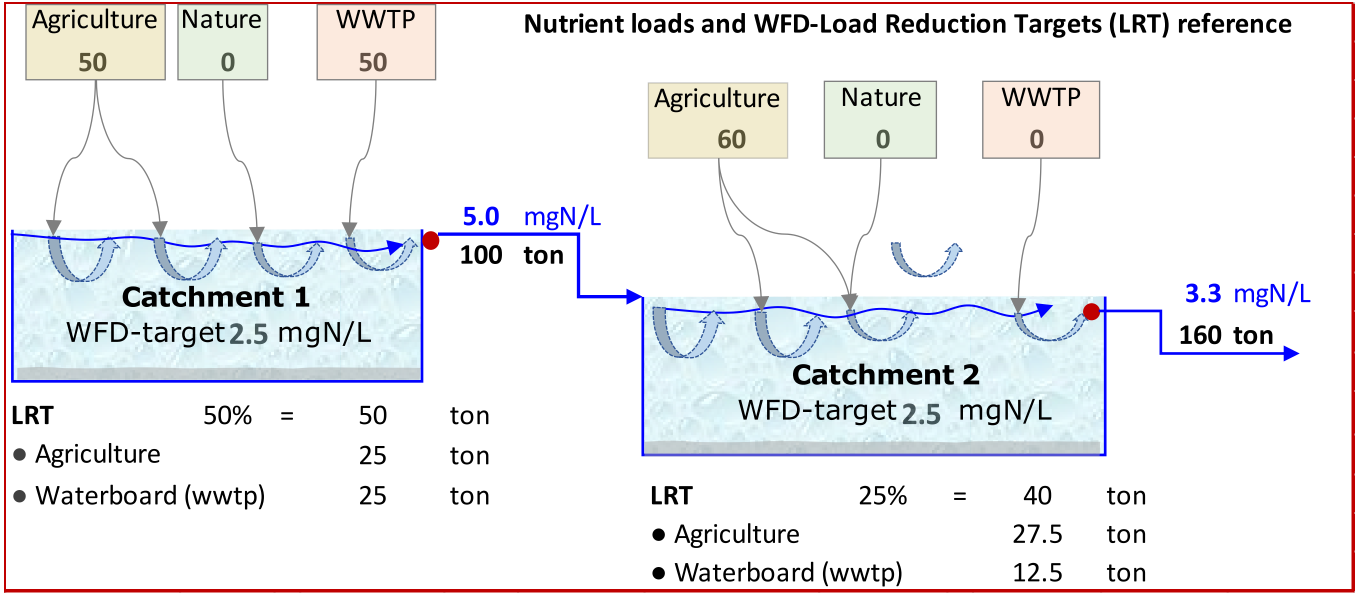
Policy makers water quality: Divide LRT over the sectors, in proportion of their contribution to the total anthropogenic load ('polluter pay principle')



Illustrative example 1

2 WFD Surface Water Bodies (SWB upstream, downstream)

2 sources: agriculture and a large wastewater treatment plant (WWTP)



Catchment 1: LRT agriculture = 50/100 * 50 ton = 25 ton

Catchment 2: LRT agriculture = (50+60)/160 * 40 ton = 27,5 ton

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This table is used to allocate total LRT over sectors, following the 'polluter pay principle'.

Not all loads are assumed to be anthropogenic!

This way to allocate LRT requires a very detailed source apportionment analyses !!

Nutrient loads		Anthropogenic sources, allocated to sector	Natural sources
Leaching and runoff from agriculture	driven by the actual and historical use of fertilizers (manure and chemical)	agriculture	
	Driven by atmospheric deposition		Natural
	Driven by natural leaching and mineralization and seepage from aquifers		Natural
Runoff from paved farmyards, discharges of spills from greenhouses, direct spills of fertilizer on ditches		agriculture	
Leaching and runoff from nature soils			Natural
Atmospheric deposition on open water			Natural
Diffuse loads from water birds			Natural
Discharges communal waste water treatment plants (WWTP)		waterboard	
Discharges from industrial waste water		Industry	
Flows from rainwater sewers		Municipality	
Overflow of sewers (mixed sewer systems)		Municipality	
Other anthropogenic sources (recreational boating, traffic, raw domestic discharges)		Waterboard and municipality	
Discharge at the Dutch border from upstream Belgian and German rivers/streams/canals		Foreign (Belgium or Germany)	

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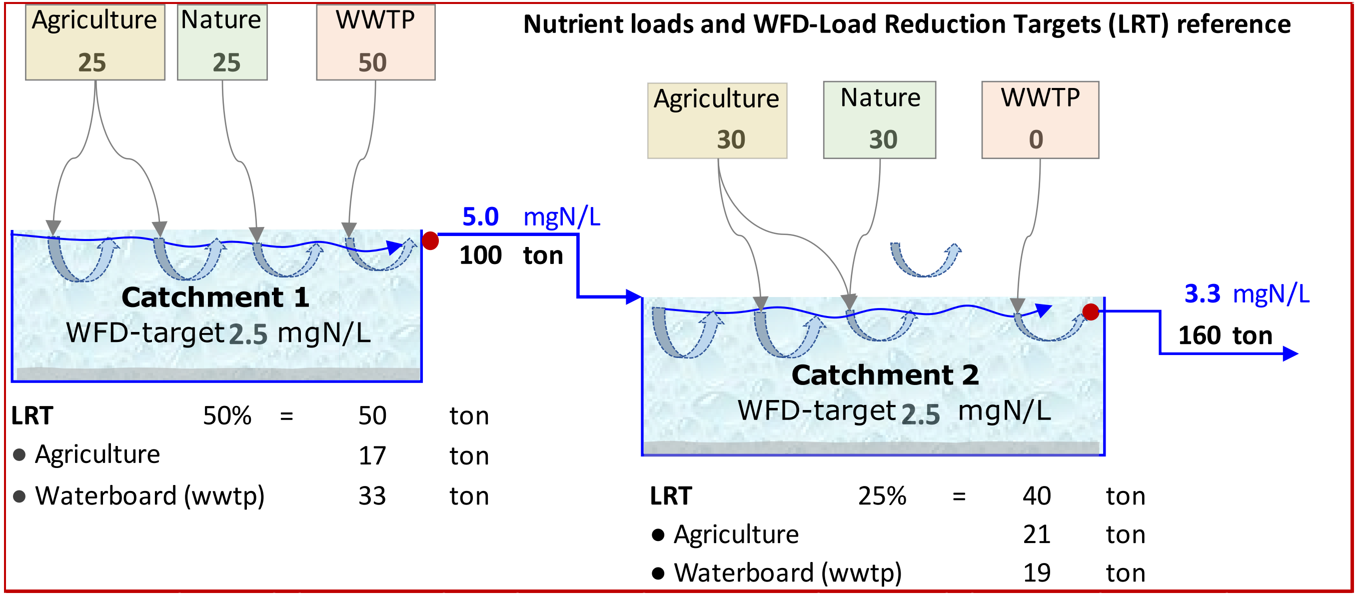
Illustrative example 2

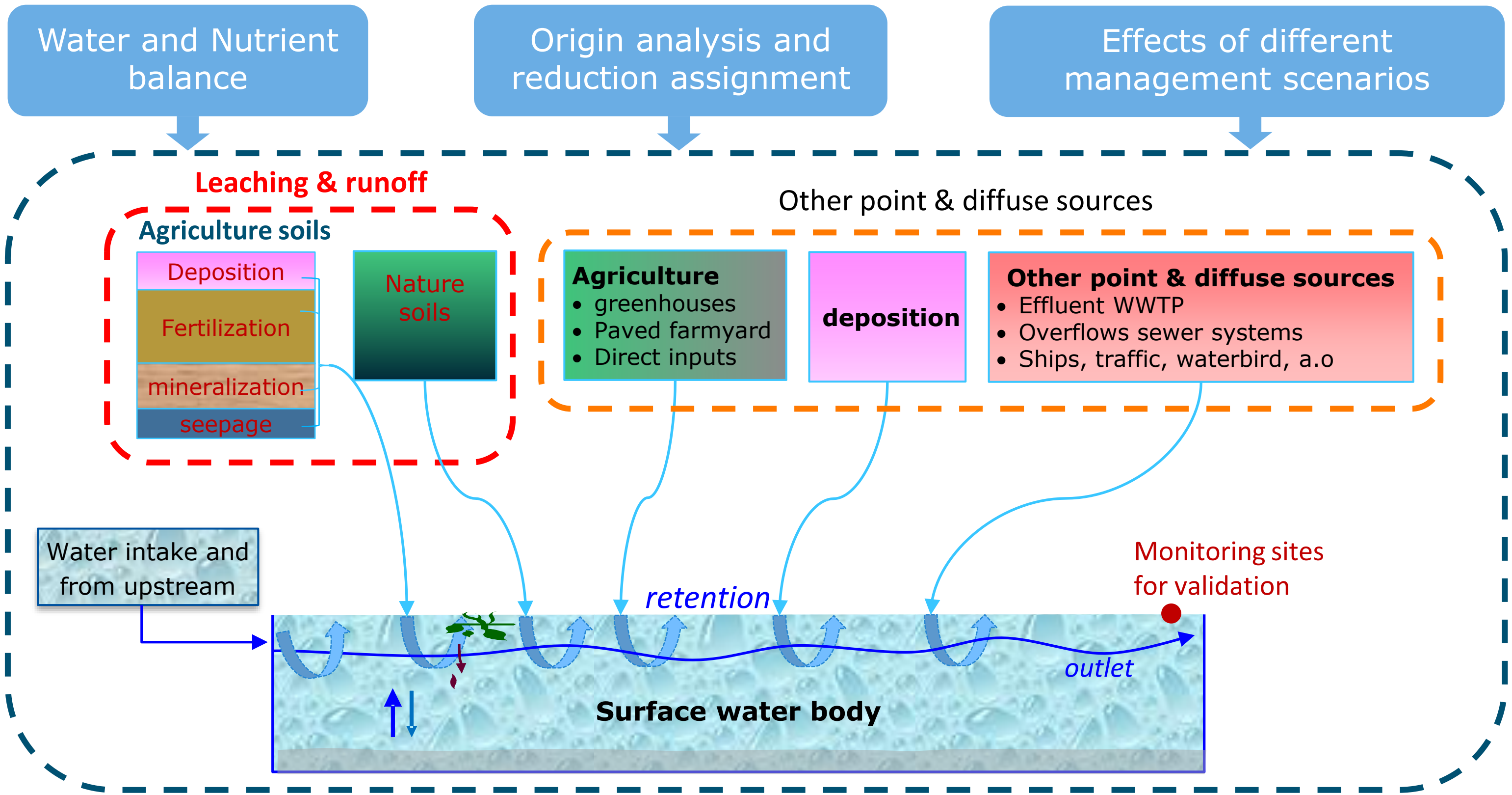
Same as example 1, but now 3 sources: half of the runoff originate from nature soils



Catchment 1: total anthropogenic load = 25 + 50 ton

LRT agriculture = 25/75 * 40 ton = 16,7 ton

Dutch source apportionment method: **WFD-ECHO**



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Steps WFD-ECHO

A. Delineation and routing surface water bodies (swb)

- ❑ **Boundaries catchments**
- ❑ **Water intake, interactions upstream → downstream**
- ❑ **Inventory measurements discharges and concentration swb**

B. Quantify sources N & P

- ❑ **Leaching & runoff agriculture & nature soils**
- ❑ **Known (registered) point sources: WWTP**
- ❑ **Other point and diffuse sources: Emission Inventory database**
- ❑ **Loads derived from measurements (model boundaries)**

C. Water en nutrient balances per catchment

- ❑ **Calculation retention**
- ❑ **Exchange of water and nutrients upstream → downstream**
- ❑ **Labeling sources for each catchment** (including water from upstream)

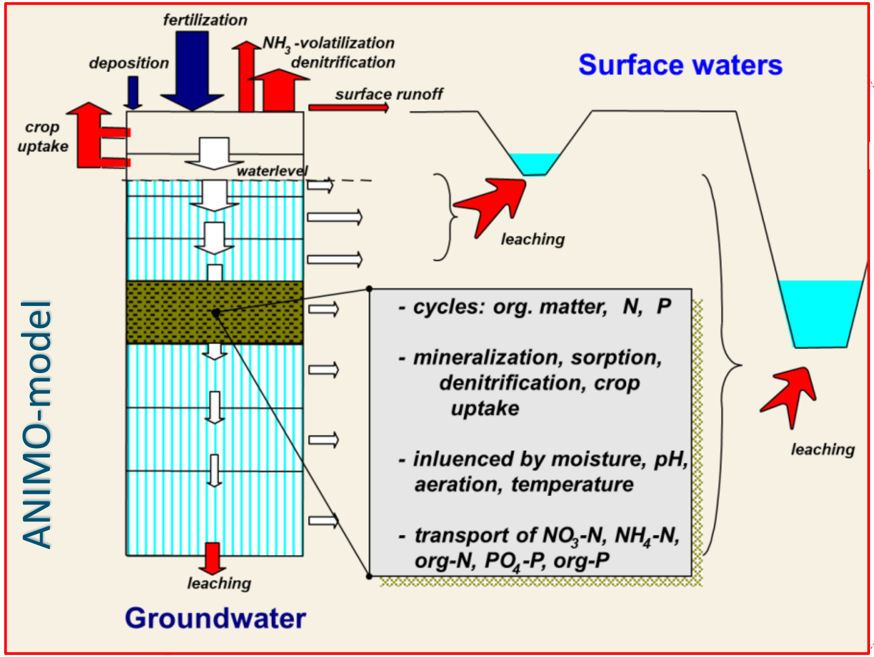
Validation

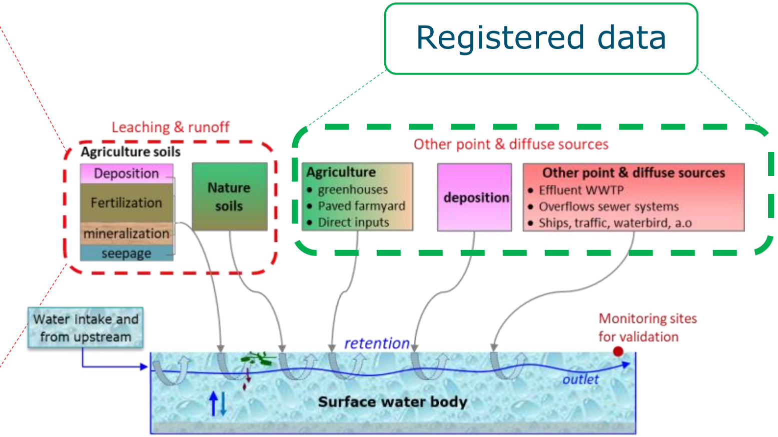
- ❑ discharges
- ❑ loads

Leaching and runoff: SWAP-ANIMO

Statistical analysis using Monte Carlo techniques, to distinguish the factors that determine leaching and runoff from agricultural soils: Leaching and runoff caused by:

- Fertilizer use (chemical and manure)
- Atmospheric deposition
- Mineralization and seepage





WFD-ECHO Dutch river basins Meuse

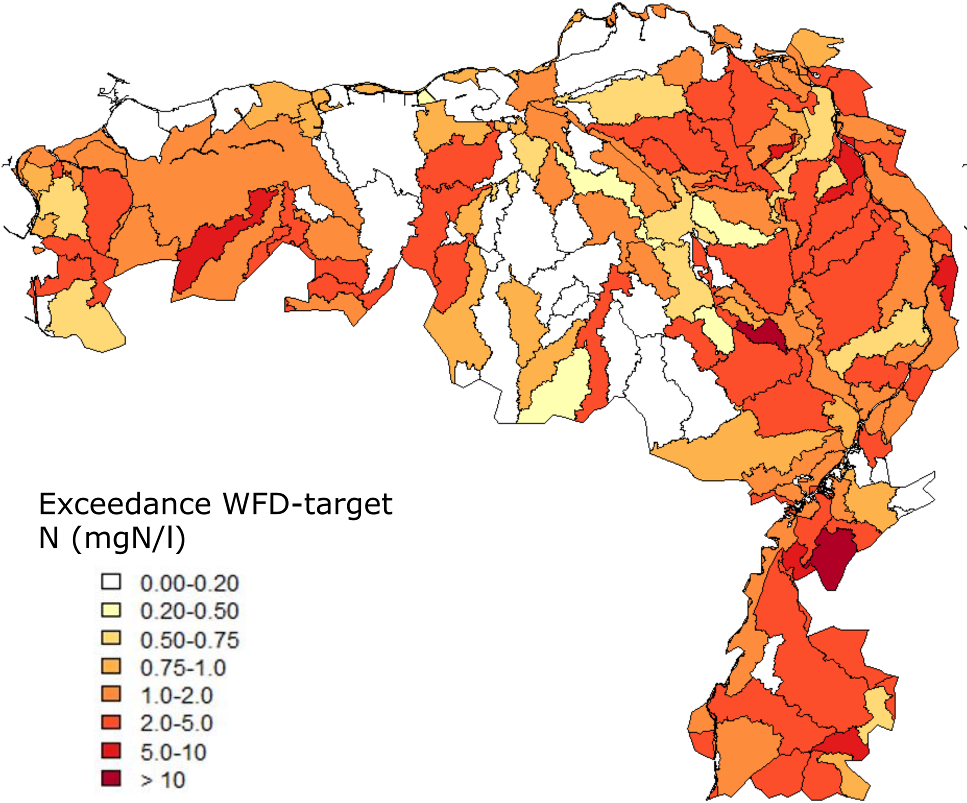
- 140 WFD Surface Water Bodies
- ≈ 50% exceeds WFD-target of N and/or P
- Main nutrient sources:
  - Agriculture
  - WWTP
  - Rivers and streams Belgium en Germany
- 4 water boards, 2 provinces

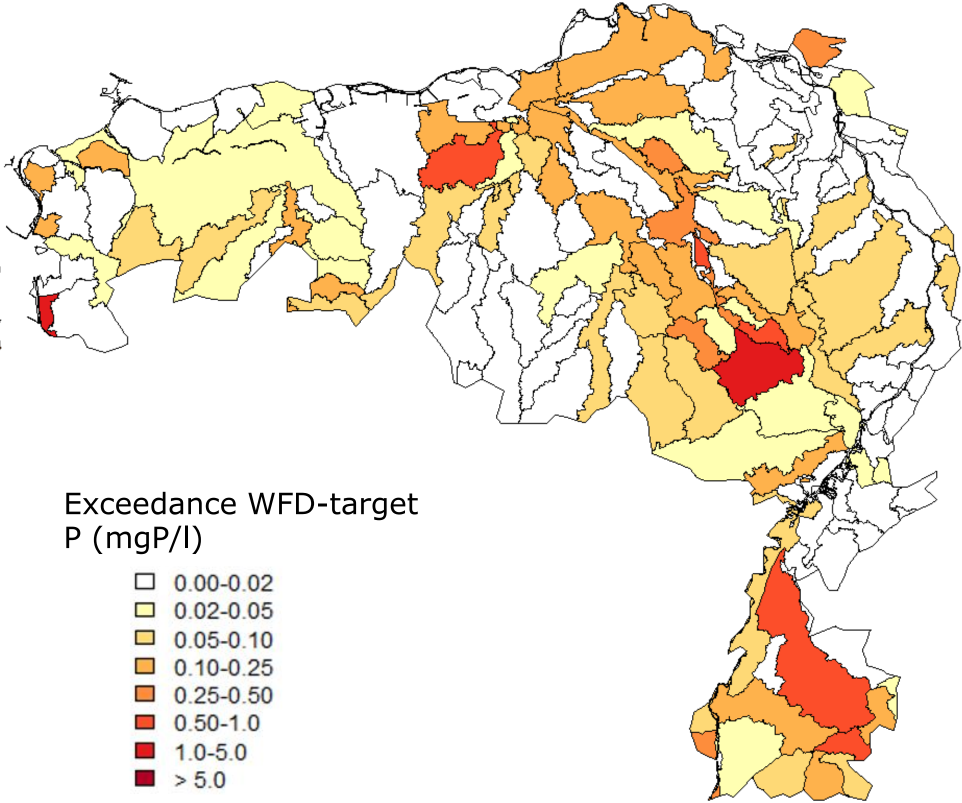
reference period LRT : 2014-2017, Summerhalfyear (Apr-Sept)

Baseline scenario : Remaining LRT 2027, assuming:

- Actual agricultural and fertilizer policy
- Measures for WWTP's (3rd RBMP)
- Transboundary rivers-streams-canals Belgium and Germany will meet the Dutch WFD-targets
- Estimated load reduction 2027 other registered point and diffuse sources (little changes)

Some results: nutrients reference period 2014-2017





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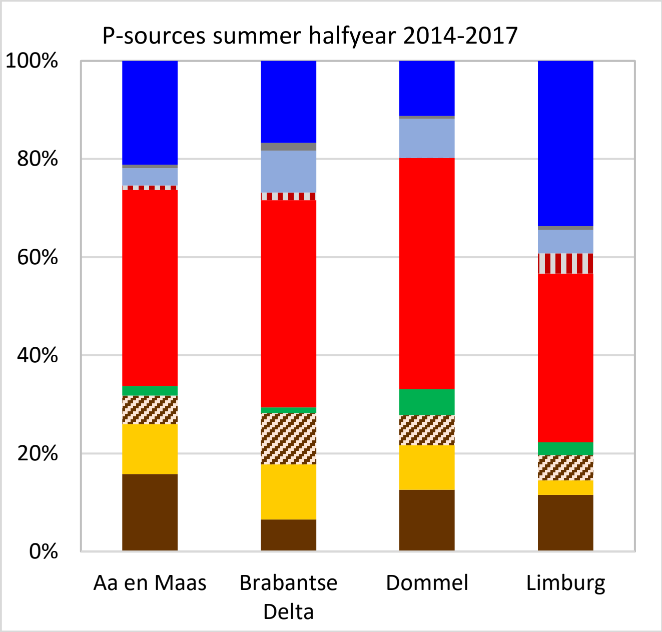
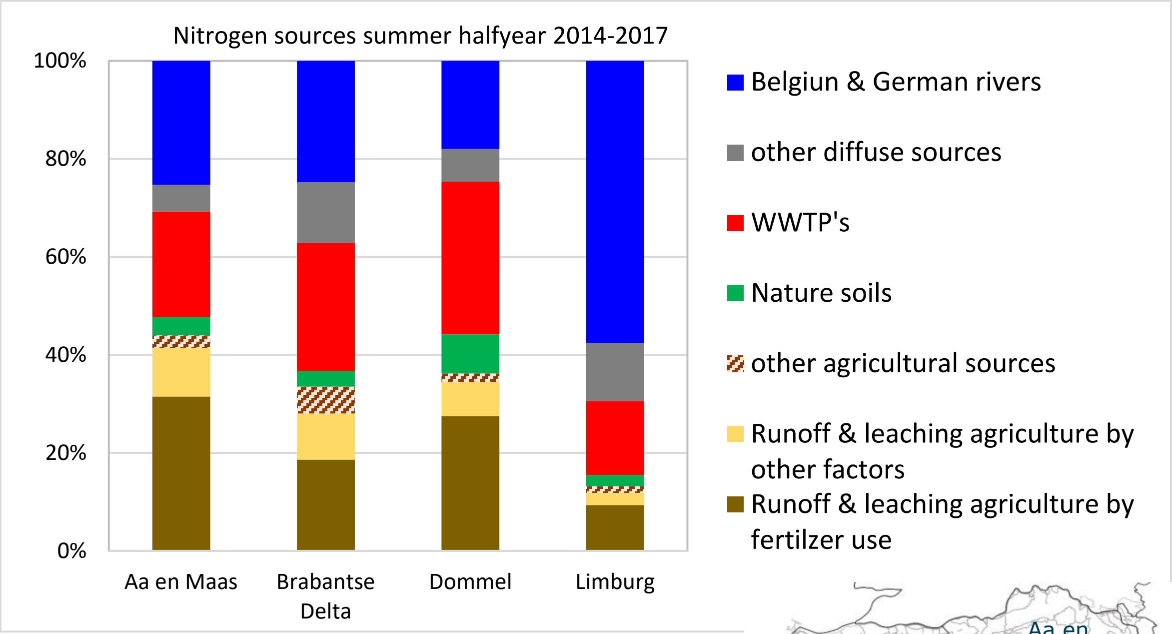
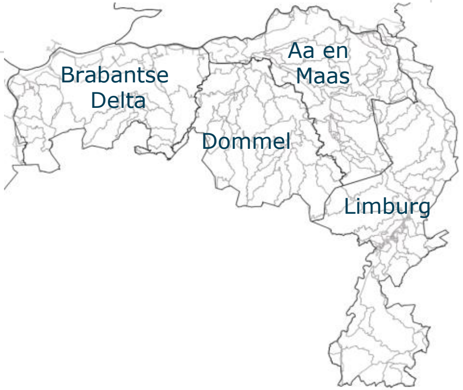
modelled contribution sources 2014-2017







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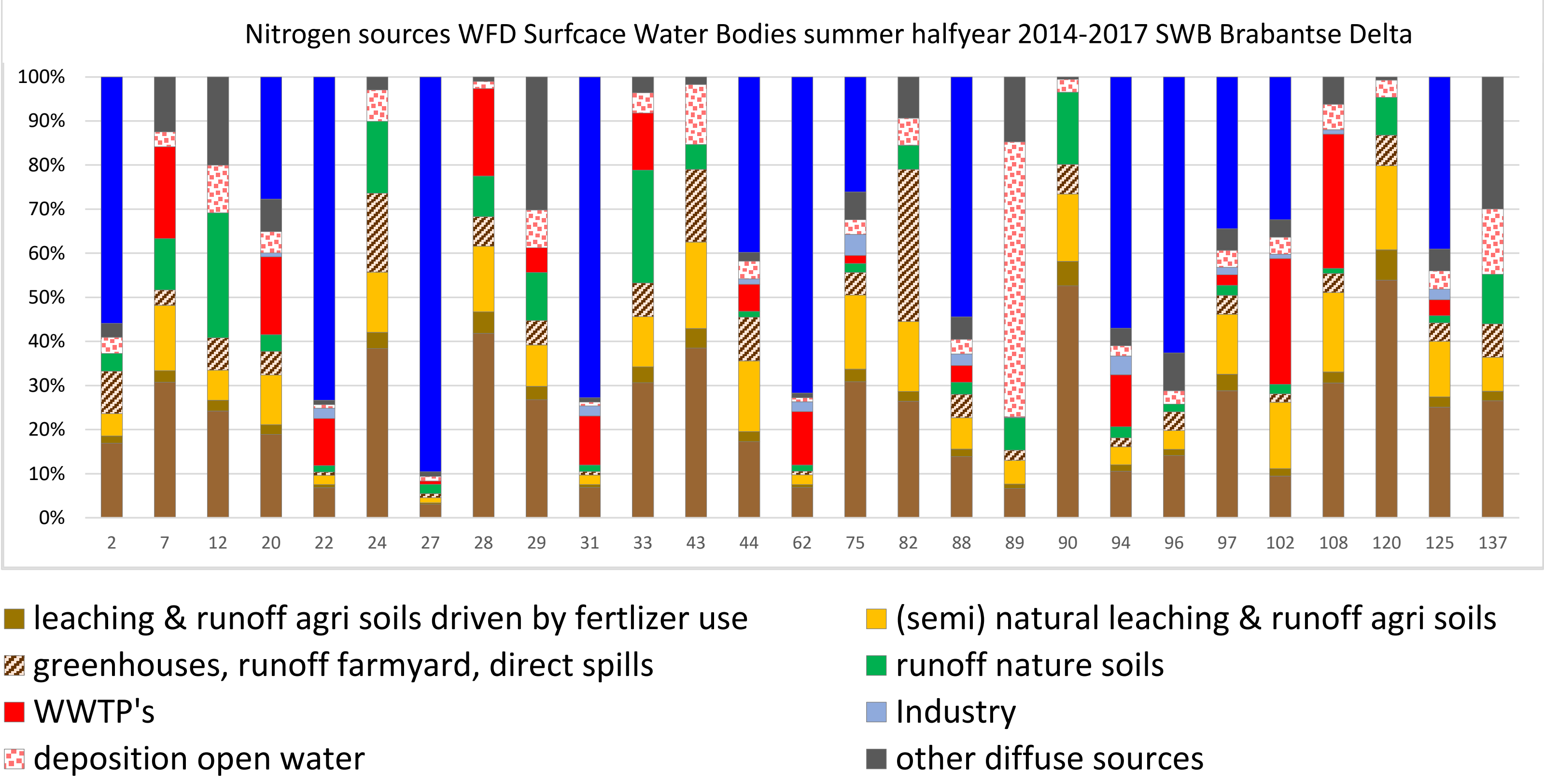
modelled contribution sources 2014-2017

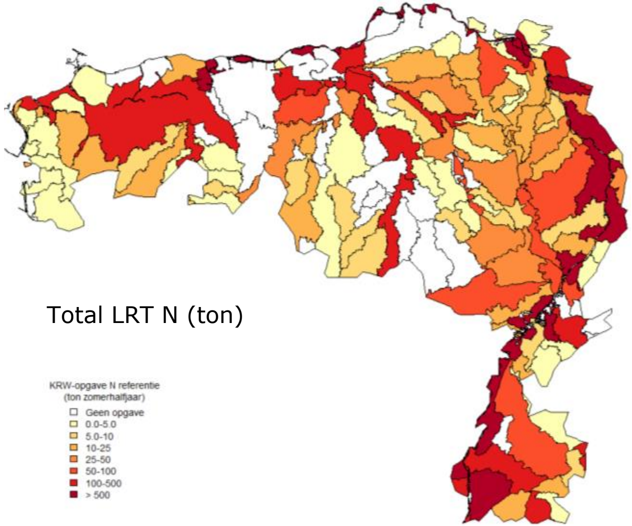
waterschap

- Aa en Maas
- Brabantse Delta
- Dommel
- Limburg

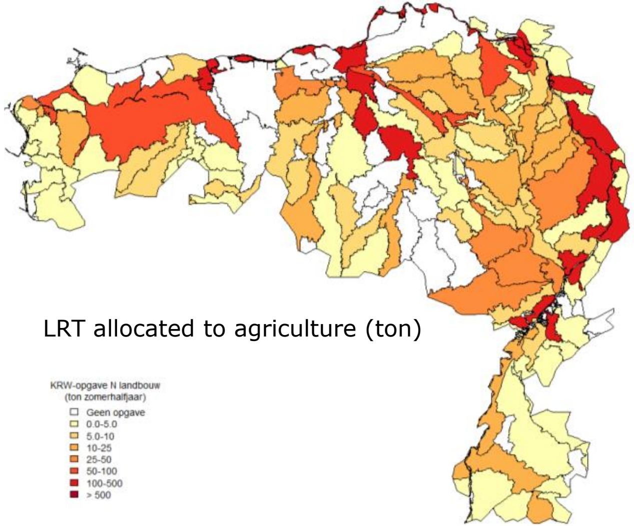


Load Reduction Targets N

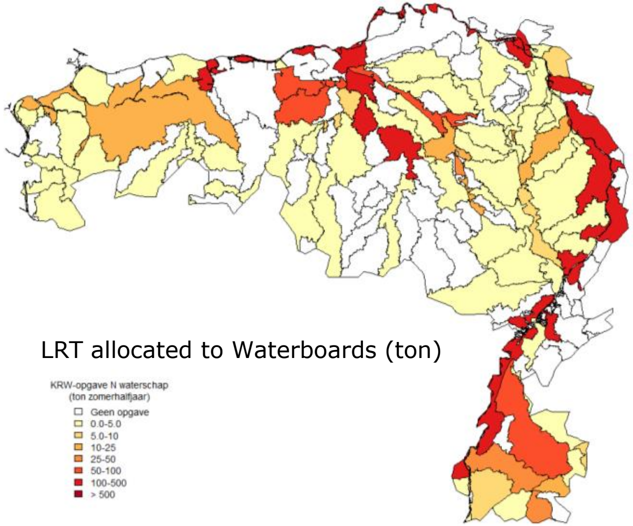
- Total LRT
- Allocated to agriculture
- Allocated to water boards
- Allocated to abroad



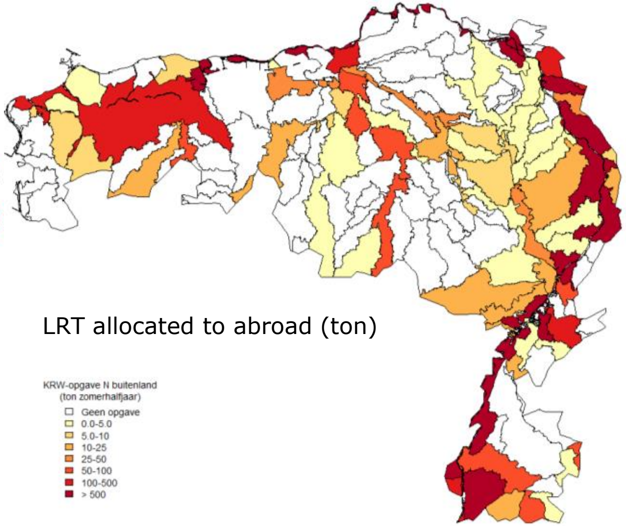
Total LRT N (ton)



LRT allocated to agriculture (ton)



LRT allocated to Waterboards (ton)



LRT allocated to abroad (ton)

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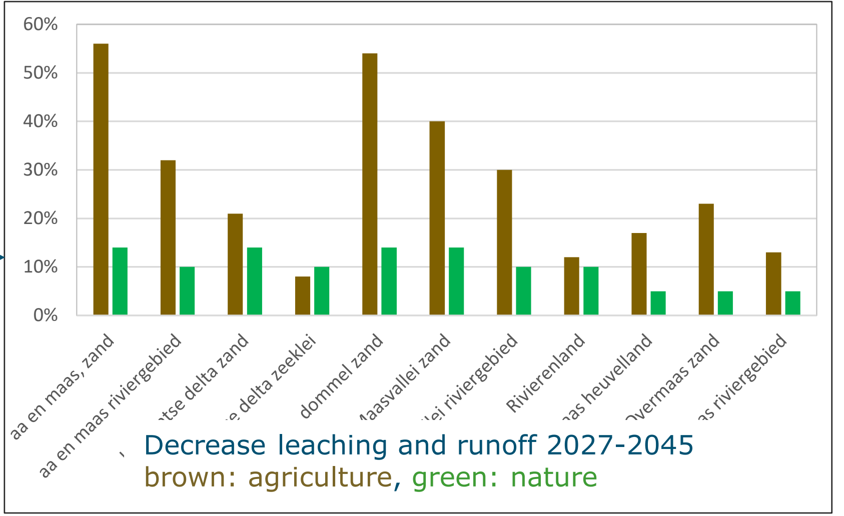
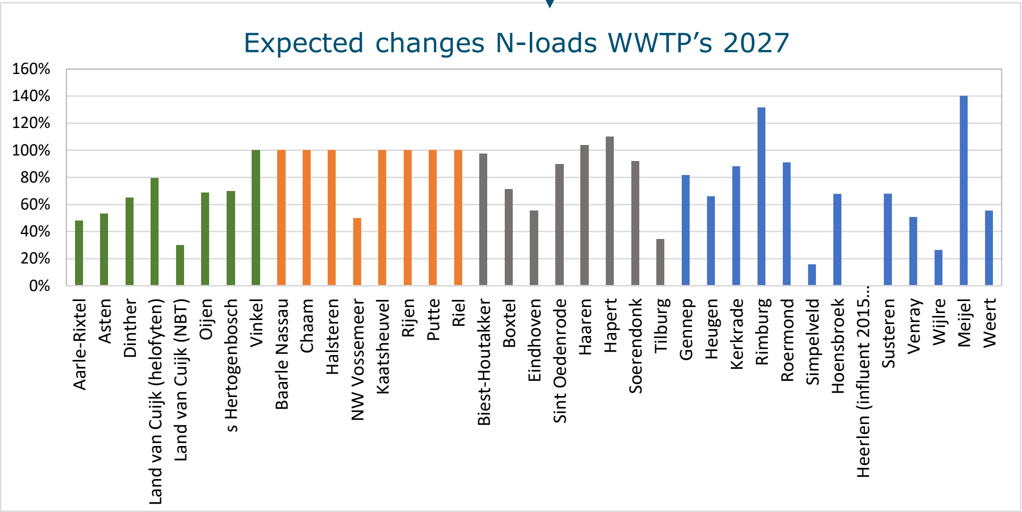
Loads 2027 baseline scenario

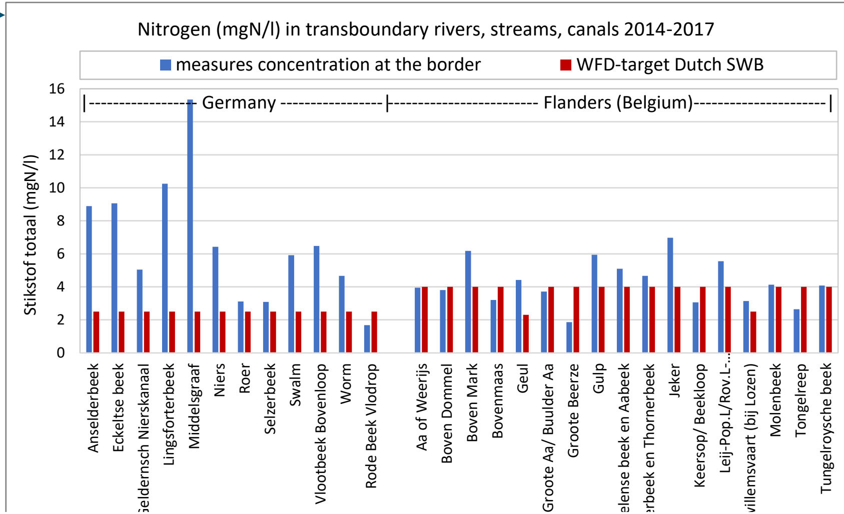
- Actual agricultural & fertilizer policy: phase out derogation, 20% less fertilizer use in nutrient polluted areas, buffer strips, catch crops

- Water quality from Belgium and Germany will meet the Dutch WFD-targets at the border

- Measures for WWTP's (3rd RBMP)

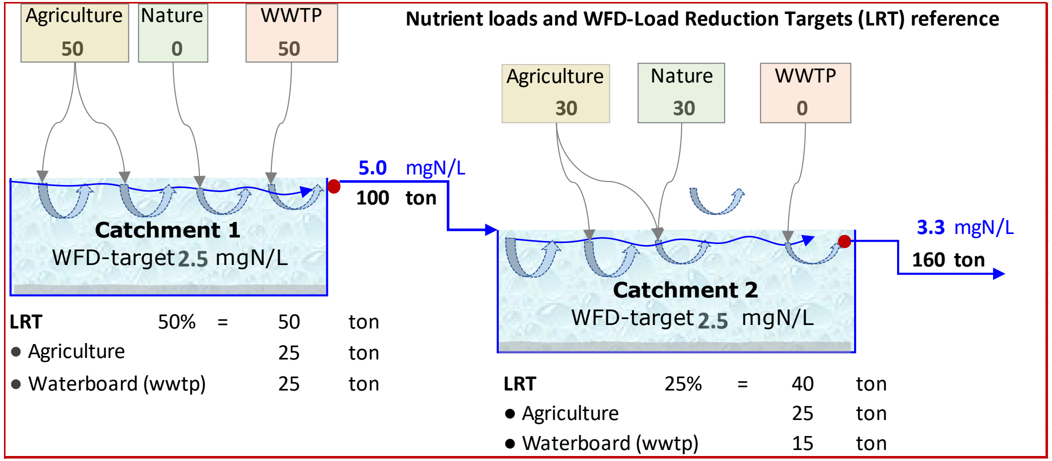






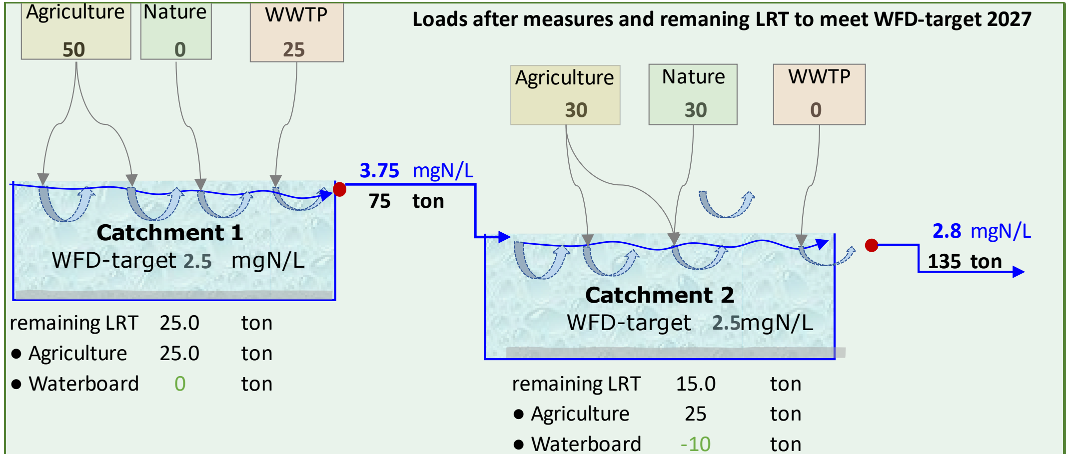
Remaining LRT 2027 after measures have been taken

LRT reference situation



Load reduction WWTP catchment 1 remaining total LRT 15 ton

- ➢ Remaining LRT waterboard 0
- ➢ Remaining LRW agriculture 25 ton (of 15?)



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Remaining LRT

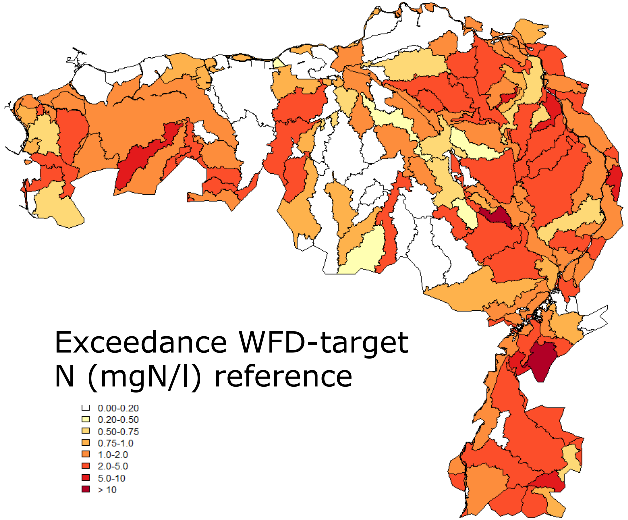
- Total
- agriculture
- water boards

Conclusions:

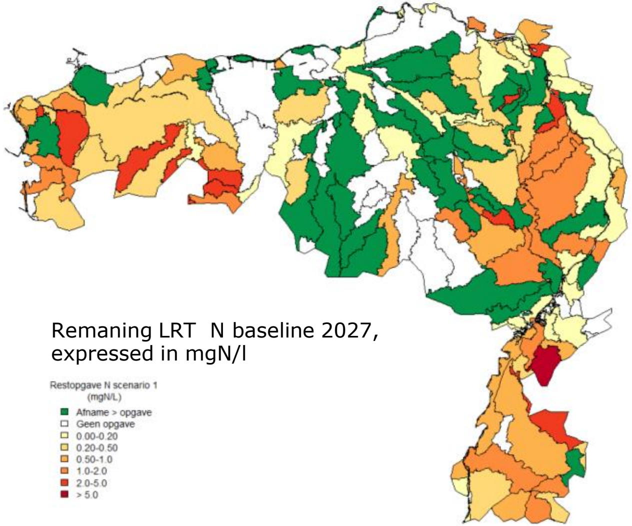
Large improvement water quality

LRT will disappear in many SWB, but not everywhere, especially not where very high exceedances are measured in the reference period

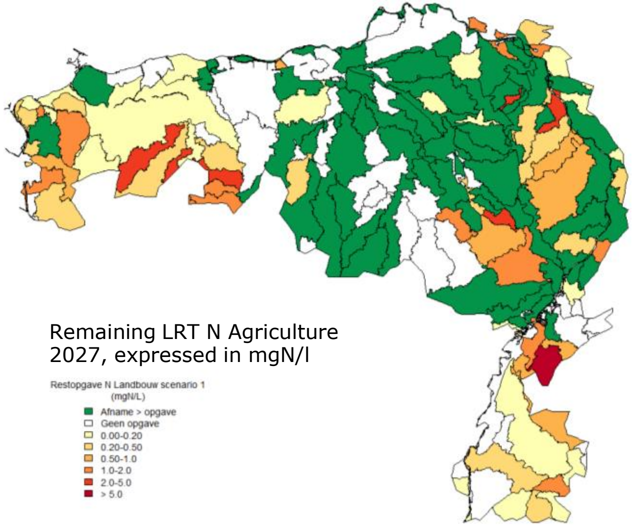
Transboundary LRT important in the Dutch Delta



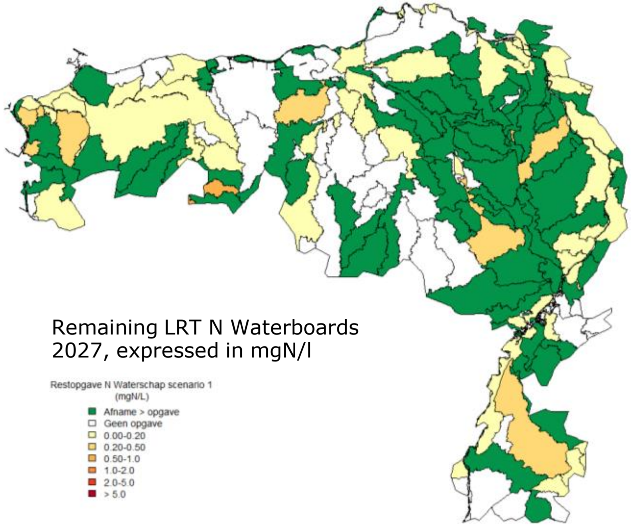
Exceedance WFD-target N (mgN/l) reference



Remaning LRT N baseline 2027, expressed in mgN/l



Remaining LRT N Agriculture 2027, expressed in mgN/l



Remaining LRT N Waterboards 2027, expressed in mgN/l

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Policy considerations Load Reduction Targets N & P

- Transparent insight balances, effects upstream-downstream useful for policy makers.
- LRT is directly related to exceedances of individual SWB, what about uncertainties modelling? (140 SWB → 140 catchments → 140 nutrient balances with 10 different sources. SWB with very high measured exceedances are not so well reflected in the model. Storm events can dominate loads
- No guidelines to decide about reference period: 2000-2009, 2017-2022, summer, whole year?
- Do we have good knowledge of natural parts of the loads (especially w.r.t. agriculture soils)
- Upstream-downstream: retention point sources differ from diffuse, WFD-targets can also differ. No LRT upstream, but the loads can cause problems in the downstream SWB or sea
- What if total LRT disappears with a policy scenario, but allocated sector LRT not?
- Cost-effectiveness not taken into account, is a whole other approach

Nutrient LRT approach to reach WFD-targets

Questions?

Research funded by: H2020 project New Harmonica, Regional waterboards and provinces, National ministries LNV & I&W

Research team: Peter Schipper, Erwin van Boekel, Piet Groenendijk, Yanjiao Mi-Gegotek, Hans Kros, Jan-Cees Voogd, Mattijs Hehenkamp, Leo Renaud

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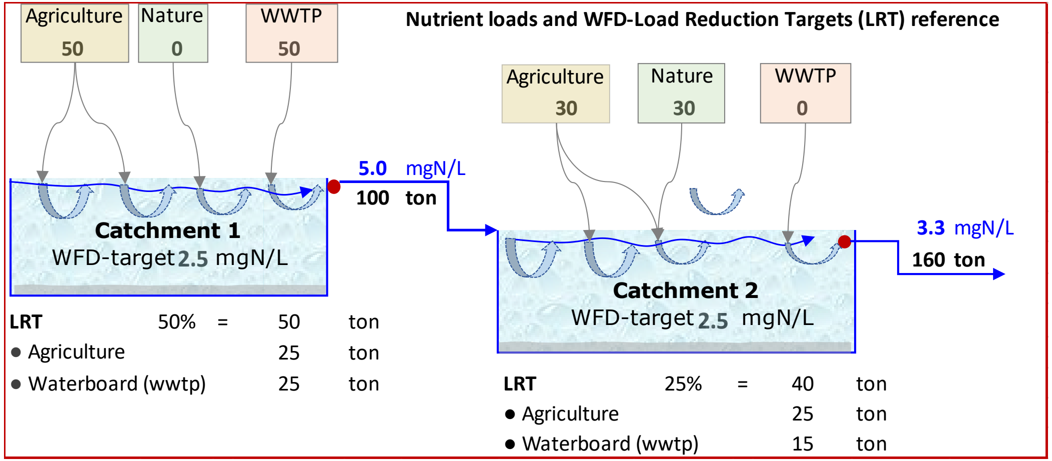
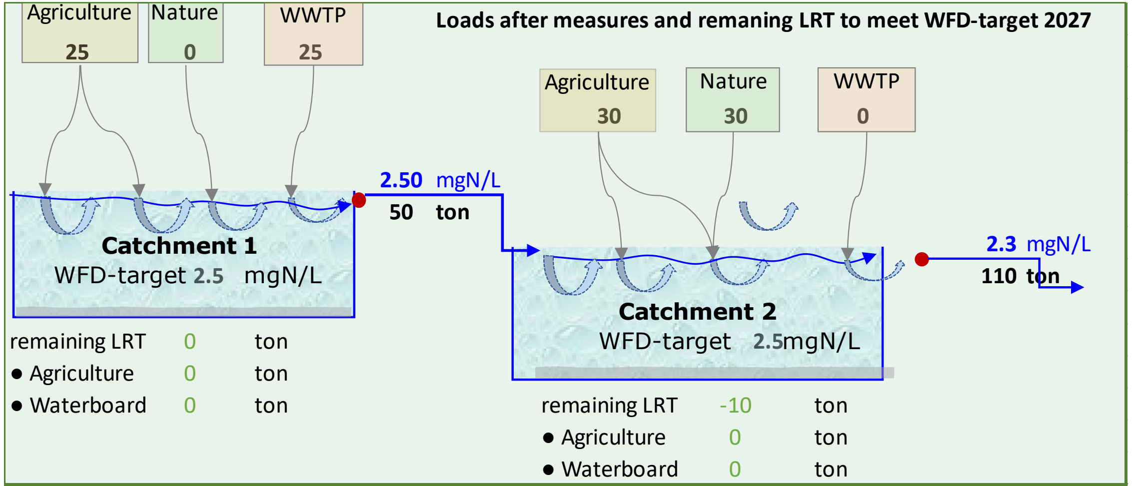
Remaining LRT after measures have been taken



Measures catchment 1 exactly result in LRT

remaining LRT in catchment 2 = zero (negative)



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Discharge and loads, comparison modelling results with measurements